

XV. MATERIALS FOR A GENERIC REVISION
OF THE FRESHWATER GASTROPOD
MOLLUSCS OF THE INDIAN EMPIRE.

INTRODUCTORY NOTE.

[Under the above title I propose, with the help of other members of the Zoological Survey of India, to issue a series of short papers embodying the main taxonomic results of our recent survey of the freshwater molluscs of India.¹ The definitions and limitations of the genera we have adopted are in many instances different from those hitherto accepted, and it will be as well that our views should be subjected to criticism, which we will welcome, before our final monograph is published. N. A.].

NO. I.—THE INDIAN GENERA OF MELANIINAE.

By N. ANNANDALE, D.Sc., F.A.S.B., Director, Zoological
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It is convenient to separate the family Melaniidae or Tiaridae into two subfamilies, the Melaniinae (or Tiarinae) and the Paludoninae, and to include in the former all the species with elongate narrow shells. Among the Indian forms with this type of shell only two genera have hitherto been generally recognized, namely *Faunus*, de Montfort and *Melania*, Lamarck (= *Tiara*, Bolten); but *Melania* has been divided into a number of subgenera, as to the names of which there has been considerable confusion. My conclusions may be introduced conveniently by a key to the genera I now recognize. Their status and limits will be discussed thereafter.

Key to the Indian Genera of Melaniidae.

1. Outer lip of shell forming a broad and prominent lobe defined above and below by well-developed canal-like prolongations of the aperture. Operculum thick, without spiral figure *Faunus*.
2. Outer lip not lobular, upper and lower canals of the aperture ill-defined or absent.
 - A. Shell very small (less than 1 cm. high), hairy, sculptured with spiral incised lines only. Operculum extremely thin, paucispiral, with the nucleus eccentric. Foot produced into a filamentous process behind. Marginal tooth of radula with three sharp denticulations and a pointed process near the base *Mainwaringia*.
 - B. Shell large or of moderate size, as a rule without hairs, with at least a trace of longitudinal grooves and ridges. Operculum at least moderately thick. Foot without posterior process.

¹ See Kemp and Gravely, *Ind. Jour. Med. Research*, VII, p. 252 (1919), &c.

- Radular teeth without basal process, either with more than three sharp denticulations or with three much broader blunt denticulations.
- i. Shell large, heavy, ovoid, with strong spines round the upper extremity of the body-whorl. Operculum without spiral figure, long, narrow, oval... .. *Melania (=Tiara).*
- ii. Shell as a rule more elongate, without, or with relatively feeble, spines. Operculum bearing a spiral figure.
- a. Shell never very thick or large and as a rule relatively long and slender, tapering to a sharp point at the apex, with the aperture ovate and never produced above, the sculpture consisting of numerous longitudinal and spiral grooves which form by their intersection a reticulate or nodular pattern, rarely obsolescent. Spines sometimes present on upper extremity of body-whorl. Operculum relatively large, ovate, paucispiral, with the nucleus situated near the inner lower margin and the spiral figure occupying only a small part of the surface. Mantle bearing on its inner surface near the margin a row of digitiform processes. Radular teeth relatively long, with numerous sharp denticulations *Melanoides.*
- b. Shell as a rule large heavier and broader, with more solid sculpture or nearly smooth, more or less biconical in outline and with the aperture frequently produced slightly both above and below. Spines never present on the upper margin of the body-whorl. Operculum relatively small, subcircular, with a spiral figure that occupies most of its surface. No processes on or near edge of mantle. Radular teeth relatively short with fewer and blunter denticulations *Acrostoma.*

Faunus and *Mainwaringia* do not belong to the freshwater fauna as both are estuarine. The geographical range of the former is wide but in the main insular, while *Mainwaringia*¹ is known only from the Gangetic delta. The synonymy and diagnosis of the two freshwater genera may be discussed further.

Genus *Melanoides*, Olivier (*nec* H. and A. Adams).

1807. *Melanoides*, Olivier, *Voy. l'Emp. Ottoman*, II, p. 40.
 1854. *Plotia*, *Melania*, *Tarebia*, H. and A. Adams, *Gen. Recent Moll.*, I, pp. 295, 301, 304.
 1874. *Melanoides*, *Melania*, s.s. (in part), *Plotia*, *Tarebia*, *Striatella*, Brot. *Conch. Cab.*, pp. 6, 7.
 1885. *Melania* (s.s.), *Striatella*, *Melanella* (in part), *Tarebia*, *Plotia*, Nevill, *Hand List Moll. Ind. Mus.*, II, pp. 221, 231, 271, 272, 280.

¹ Annandale & Prashad, *Rec. Ind. Mus.*, XII, p. 251, fig. 5, pl. xx, fig. 8 (1919).

1897. *Stenomelania, Melanoides, Plotia, Tarebia*, von Martens in Weber's *Zool. Ergebn. Reis. Niederl. Ost-Ind.*, IV, pp. 40, 50, 62, 69.
 1898. Neomelaniën (in part), P. and F. Sarasin, *Sussw. Moll. Celebes*, p. 38.
 1915. *Radina, Striatella, Melanella* (at least in part), *Tarebia, Plotia*, Preston *Faun. Brit. Ind., Freshw. Moll.*, pp. 10, 15, 32, 33, 35.
 1919. *Melanoides*, Annandale and Prashad, *Rec. Ind. Mus.*, XVIII, p. 28.

There has been much confusion in nomenclature owing to the fact that H. and A. Adams used the name *Melanoides* in quite a different sense from that in which it had been introduced thirty-seven years earlier by Olivier, who applied it to a race or phase of the common "*Melania*" *tuberculata*. A reference to this author's "voyage" shows that Nevill (*op. cit.*, p. 248) was wrong in stating that the form of the name employed was "Melanoïde," a form that might not have been considered valid, and Preston has ignored von Marten's remarks on the subject.

M. tuberculatus (Müller), the type of this genus, is perhaps the most widely distributed of all the non-marine Gastropods that occur in India, for it is found in most parts of the Oriental and Ethiopian regions and even in parts of the Palaearctic and Australasian Regions adjacent to them. With this species a large number of Oriental forms must be associated generically on account of the fact that they possess the characters noted in the key. The Sarasins were the first authors to lay stress on the peculiarities of the radulae and opercula of these forms, but they were apparently not acquainted with the peculiarities of the mantle. They did not regard the structures they examined as of generic importance and associated species I retain in *Melania* with those here assigned to *Melanoides* in their group "Neomelaniën."

The description given in the key, with the figures published in the various works to which I have referred, should render the recognition of species of the genus easy, if the animal as well as the shell be examined. The processes of the mantle are arranged in a small series along a line running parallel to the margin. As a rule they increase in size from left to right. When the animal is fully expanded they are elongate and pointed and often resemble small parasitic leeches protruding from the mouth of the shell. In preserved specimens they are as a rule contracted and much less conspicuous.

Genus *Acrostoma*, Brot.

1854. *Melanoides*, H. and A. Adams (*nec* Olivier), *Gen. Recent Moll.*, I, p. 296.
 1874. *Melanoides, Acrostoma*, Brot, *op. cit.*, p. 7.
 1885. *Melanoides, Acrostoma*, Nevill, *op. cit.*, pp. 248, 270.
 1897. *Brotia*, von Martens, *op. cit.*, p. 33.
 1898. Palaëomelaniën, P. and F. Sarasin, *op. cit.*, p. 30.
 1915. *Melanoides, Acrostoma*. Preston, *op. cit.*, pp. 21, 30.

I cannot find any difference of generic importance between the soft parts, radula, operculum or shell of *Brotia*, von Martens (= *Melanoides*, *op. cit.*) and *Acrostoma*, Brot. Indeed, in the single species I call *Acrostoma variable* (Benson) an almost complete

gradation can be observed. In the type-species of *Acrostoma* (*A. hügelii*) the structure is similar in every respect to that of *A. variabile* and the shells of certain individuals of the latter are by no means unlike those of the former.

I have been able to find no trace of digitiform processes on or near the edge of the mantle in either living or preserved specimens of *A. variabile* or in preserved specimens of *A. hügelii*. In both, however, there is a peculiar arrangement of the pigment on the inner surface of the mantle. It is distributed in alternate longitudinal dark and pale streaks, the pale pigment in the living animal being of a bright yellow colour but fading to white in spirit.

Some of the largest of the freshwater Mollusca are included in this genus. It is usually found in running water, but *A. variabile* is common in ponds in Calcutta. The headquarters of the genus are in Burma and the Sunda Is., but the type-species has an apparently discontinuous range in Assam and South India, and *A. variabile*, though mainly Assamese and Burmese, extends for some distance up the Ganges.

I am not yet quite sure as to the generic position of the Burmese species assigned by Nevill and Preston to *Pachychilus*, Lea. They are probably dwarf forms of *Acrostoma* and do not seem to be closely related to the Central American species for which the genus *Pachychilus* was originally used.

Genus *Melania*, Lamarck.

- (1798. *Tiara*, Mus. Bolten.)
 1799. *Melania*, Lamarck, *Prodromus*.
 1854. *Tiara*, H. and A. Adams, *op. cit.*, p. 294.
 1874. *Tiara*, Brot., *op. cit.*, p. 7.
 1884. *Tiara*, Nevill, *op. cit.*, p. 278.
 1897. *Melania*, s.s., von Martens, *op. cit.*, p. 66.
 1898. Neomelaniens (in part), P. and F. Sarasin, *op. cit.*, p. 38.
 1915. *Tiara*, s.s., Preston, *op. cit.*, p. 10.

The distribution of this genus is mainly insular and largely Pacific. Within the limits of the Indian Empire it is found only in the Nicobars and (doubtfully) in one of the Anadaman Islands. I know nothing of the animal, but the shell and operculum are very distinct from those of *Melanoides* or *Acrostoma*. Troschel¹ and P. and F. Sarasin (*op. cit.*) describe and figure the radular teeth of species of *Melania* as very like those of *Melanoides*, with which the latter authors associate these species in their group of Neomelaniens. The type-species is *Helix amarula*, Linn. Those interested in the revival of forgotten generic names may refer to Dall's² account of the *Museum Boltenianum*, reviewed in the *Ann. Mag. Nat. Hist.* (8) XVI, p. 232 (1915) by "B.B.W."

¹ Troschel, *Geb. der Schnecken. z. Begründung ein. nat. Classification*, I, pl. viii (Berlin: 1856-1863).

² Dall, *Misc. Publ. Smithsonian Inst.* No. 2360 (1915). Not available to me.

No. II—THE INDIAN GENERA OF VIVIPARIDAE.

By N. ANNANDALE, D.Sc., F.A.S.B.

Until recently all the Indian species of this family have been placed in the genus *Vivipara*, Montfort; but in 1918¹ I separated certain forms from Upper Burma and the Shan States under the name *Taia*, while still more recently² I have described three fossil or subfossil subgenera of this genus from the same country. In the present paper I give reasons for regarding one of these (*Temnotaia*) as generically distinct and put on record the occurrence of a living species in Upper Burma. An examination of the animal of Benson's *Paludina lecythis* proves that it and its allies must also be separated from *Vivipara*. I propose for them the new generic name *Lecythoconcha*.

Key to the Indian Genera of Viviparidae.

1. Columellar callus of shell broad and plate-like.
 - A. Sculpture usually consisting of prominent nodular, squamose or spinulose spiral ridges and of coarse longitudinal striae. Operculum with an internal scar of oval or ovate outline and without a rounded boss in the centre of the scar. Mantle of adult with a rather feeble sphincter muscle and a smooth or lobular margin *Taia*.
 - B. Shell smooth or with incised spiral lines. Operculum as in *Taia*. Soft parts and radula unknown *Temnotaia*.
2. Columellar callus not plate-like. Sculpture minute or including smooth spiral ridges.
 - A. Shell of small or moderate size, conical or conoidal. Operculum as in *Taia*. Mantle with the sphincter muscle moderately developed and prominent; its margin bearing in the young well-developed digitiform processes, which persist in the adult of some species *Vivipara*.
 - B. Shell large and globose. Operculum with a well-defined funnel-shaped pit on the external surface corresponding to a smooth, prominent rounded boss in the centre of the internal muscular scar, which is ring-shaped and poorly developed. Mantle sphincter very strong and prominent; mantle itself greatly thickened and highly muscular, bearing three digitiform processes in the young, smooth in the adult *Lecythoconcha*.

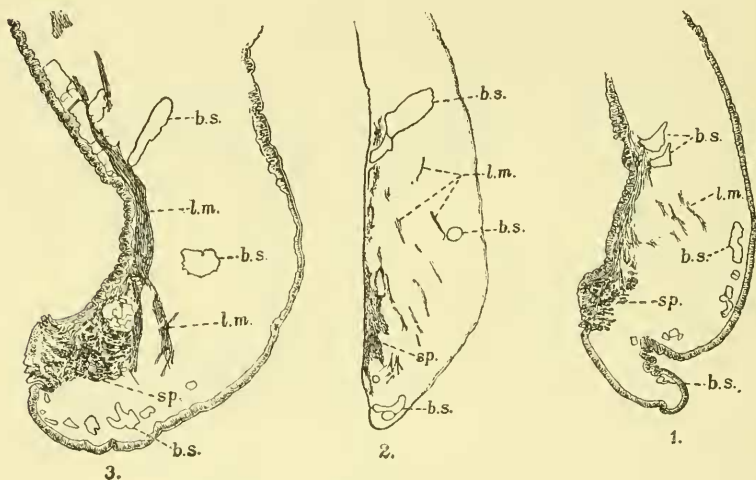
An examination of the mantle in these genera shows that it provides good generic characters. In all it is highly vascular, but in *Taia* and *Vivipara* it is thin and has a comparatively feeble musculature, while in *Lecythoconcha* it is much thickened and has both longitudinal and transverse muscles very strongly developed. In all three genera the transverse muscles are congregated on the outer surface a short distance above the margin. It is probable that all the Oriental species of the family have digitiform pro-

¹ *Rec. Ind. Mus.*, XIV, p. 123 (1918).² *Rec. Geol. Surv. Ind.*, L, p. 231 (1919).

cesses¹ on the extreme edge of the mantle in the young. In those species in which the shell of the adult possesses smooth spiral ridges of a dark colour (notably *Vivipara oxytropis*) the processes persist in the adult, but in those that have smooth unicolourous shells they become small and inconspicuous or disappear altogether. In *Taia*, in which the spiral ridges are never quite smooth, but as a rule nodular, squamose, or even spinulose, there are no such processes in the adult, and they are also absent in the somewhat similar Chinese genus *Margarya*; but apparently temporary lobes of the mantle-edge can be thrust into the small concavity at the base of each nodule, scale or spine. I hope to elaborate this point on another occasion.

Genus *Vivipara*, Montfort.

This genus is so well known that it is unnecessary to give a full description. The Indian species fall naturally into four



Vertical sections through the mantle-edge of Indian Viviparidae.

1. *Vivipara oxytropis*. 2. *Taia intha*. 3. *Lecythoconcha lecythis*.
b.s. blood-space; l.m. longitudinal muscle, sp. transverse sphincter.

groups, which may be named after the type-species of each as follows:—

VIVIPARAE BENGALENSES. The shell is normally of moderate size, occasionally large, as a rule thin but thickened in certain phases. The whorls of the spire are not greatly swollen and the suture is not deeply impressed. The outline is ovate, but varies considerably. Spiral bands darker than the rest of the shell are always present, though sometimes obsolescent. They are never very numerous and vary considerably in breadth. In some forms these bands become thickened to form ridges and there is often a

¹ I can find no reference to these processes in the European forms. Erlanger (*Morph. Jahrb.*, XVII, pl. xxii: 1891), and other authors figure the edge of the mantle in the fully formed embryo as smooth.

tendency for the outline of the body to become biangulate owing to two of them assuming the form of carinae. Corresponding to these bands there are on the edge of the mantle an equal number of small digitiform processes. The operculum is thin, sharp round the periphery and with the internal muscular scar moderately developed. The radular teeth are normal. Their denticulations are by no means large and the central lobular process of the free edge of the central tooth is broad and quadrate or triangular.

I believe that all described Indian forms¹ of this group can be comprised in the single species *Vivipara bengalensis* (Lamarck), of which several distinct races and phases can be distinguished. Major Sewell and I hope to describe it in detail shortly. It is found in all parts of the plains of the Indian Empire at which there is perennial still water.

VIVIPARAE OXYTROPIDES. The shell is large or small, thin, acuminate and more or less distinctly biconical. The whorls of the spire are not at all swollen and the suture is less impressed than in *V. bengalensis*. Dark spiral bands are present. They are always more or less thickened, at any rate in the young, and in the typical species form prominent ridges in the adult. The peripheral band forms a prominent keel, separating the shell into two regions. The region below it is obliquely flattened on the ventral surface. The operculum and radula resemble those of *V. bengalensis*, but in the typical species the marginal processes of the mantle are much larger in the adult.

Only one species of this group has as yet received a name, viz. *V. oxytropis* (Benson), but another, smaller and less specialized species, awaits description. The former is apparently endemic in the Manipur valley, while the latter occurs in the plains of the eastern part of Assam.

VIVIPARAE DISSIMILES. The shell is always small, rather high and narrow, never very sharply acuminate, moderately thin or thick, with the whorls of the spire swollen and the suture deeply impressed. There are no dark spiral bands or prominent spiral ridges, but a minute spiral sculpture of punctured lines can often be detected. There is often a broad but rather obscure pale transverse bar on the body-whorl. The operculum is thicker than in the other three sections and the muscular scar better developed. Round the periphery of the operculum there is often a thickened spongy ridge. The edge of the mantle is smooth in the adult. The central lobe of the central tooth of the radula is rounded.

Most of the forms that belong to this group are classified by Nevill² as varieties of *V. dissimilis* (Müller), but I think that he has included several species. Pilsbry³ regards the characters of the operculum as subgeneric and has given the subgeneric name

¹ *V. nagaensis*, Preston may be distinct, but I have not seen the species. I have another (undescribed) from Manipur.

² Nevill, *Hand List Moll. Ind. Mus.*, II, pp. 27-30 (1885).

³ Pilsbry, *Proc. Ac. Nat. Sci. Philadelphia*, LIII, p. 188 (1901).

Idiopoma to a Burmese species, *V. henriadensis*. These characters, however, are adaptive and are not found either in all species of the group, or even in all individuals of the species in which they are present. They are connected with the habit of aestivation in drying mud, the Viviparæ dissimiles being found mainly in bodies of water liable to desiccation. The species are widely distributed in the plains of Peninsular and North-Western India and in the drier regions of Burma.

VIVIPARÆ SINDICAE. Shells of this group are distinguished by their very pale colour, by the absence of distinct spiral bands and by the thinness of the operculum, in which the muscular scar is very feebly developed. Nothing is known of the anatomy.

The only Indian species is *V. sindica* (Nevill) from Sind, but another occurs in Seistan. Kobelt has caused great confusion in the *Conch. Cab.* by basing his description¹ and figures of this form on the type-series of Nevill's *Paludina dissimilis sindica*, which I regard as a distinct species, and conversely describing and figuring specimens from Seistan as *sindica*. His *hilmendensis* is, therefore, an absolute synonym of *sindica* (Nevill). I propose for the Seistan species the name *V. helmandica*.

Genus *Lecythoconcha*, nov.

The shell is of large, sometimes of relatively gigantic size, but never very thick; it is smooth or with obscure and never very prominent sculpture and always translucent when fresh; it is globose in form, with broad swollen whorls, and often bears a striking superficial resemblance to that of *Pachylabra* (Ampullariidae). The colour is uniform or nearly so, as a rule rather bright olive green, often with irregular blackish longitudinal lines. The aperture is large and patent, subcircular or broadly ovate. The columellar fold is not strongly developed, the umbilicus narrowly perforate and the outer lip thin.

The operculum is large, thin, horny, stiff and brittle. Externally it is marked with fine but prominent concentric ridges and bears a deep, funnel-shaped pit in a subcentral position. On the internal surface this pit is represented by a smooth, prominent rounded boss, which is surrounded by a smooth or minutely granular area representing the muscular scar.

The animal differs from that of *Vivipara* in the greatly thickened and very muscular free edge of the mantle, the sphincter muscle running along it is very prominent and unusually well developed. There are three marginal processes in the young, but none in the adult.

The radula is identical with that of *Vivipara*.

Type-species. *Paludina lecythis*, Benson.

Geographical Range. The range of the genus probably extends from Manipur (and possibly Sylhet) in the west through

¹ This description was originally published in *Nachr. Malak. Ges.* LX, p. 161 (1908).

Upper Burma and across China to the Philippines, Formosa and Japan, but I am not sure as to the generic identity of some of the Far Eastern species.¹ The only one of those of which I have been able to examine the soft parts is *Vivipara chinensis* (Gray) from Yunnan. This species, from which I regard *L. lecythis* as specifically distinct, agrees in the structure of the mantle and operculum with the type-species of the new genus.

All the Asiatic genera of the Viviparidae are closely similar in anatomy, but the structure of the mantle-edge and its sphincter is characteristic.

Genus *Taia*, Annandale.

1918. *Taia*, Annandale, *Rec. Ind. Mus.*, XIV, pp. 123, 160.

1919. *Taia*, *id.*, *Rec. Geol. Surv. Ind.*, L, p. 231.

I have already discussed this genus in the papers cited and here need only give my reasons for regarding the subfossil *Temnotaia incisa* as generically distinct. In the key on page 111 I have pointed out the distinctive characters of the mantle.

Temnotaia, Annandale (1919).

1919. *Temnotaia* (subgenus of *Taia*), Annandale, *Rec. Geol. Surv. Ind.* L, p. 231.

The discovery of a recent specimen² of *Temnotaia* in the old collection of the Indian Museum renders it advisable to enlarge the original description slightly and to separate the species generically from *Taia*.

The shells of the genus thus proposed are rather narrowly ovate, externally smooth and without prominent spiral sculpture but bearing rather coarse longitudinal striae and either microscopic spiral striae or well-defined incised lines. There are $5\frac{1}{2}$ to $6\frac{1}{2}$ whorls, and the spire is exerted and acuminate. The mouth of the shell is ovate, with the outer lip thin and not at all expanded and the columellar margin flattened, plate-like and polished, resembling that of *Taia*. In the only fresh specimen examined there are no dark spiral bands and the external surface is highly polished. The operculum is thin and resembles that of *Taia*. Nothing is known of the radula or soft parts.

Only two species have as yet been discovered, namely *T. incisa* (Annandale), found in an apparently subfossil condition in the Chindwin watershed, and *T. bhamoensis* (Nevill) from north-eastern Burma. The genus may thus be regarded as characteristic of the fauna of Upper Burma. It is apparently related to the Indo-Chinese *Chlorostracia*, Mabille, but the shell is much less globose and the mouth narrower.

¹ For one, the common species in Lake Biwa, Japan, I am proposing a new genus in a paper to be published in the *Journal of the Asiatic Society of Bengal*.

² This specimen is labelled as the type-specimen of Nevill's *Paludina dissimilis*, subvar. *bhamoensis*, but the resemblance to the Viviparæ dissimilis is quite superficial and the structure of the mouth entirely different.